Quallion Technology

1. Zero Volt Storage Capability
2. SaFE-LYTE Technology
3. Matrix Battery Pack

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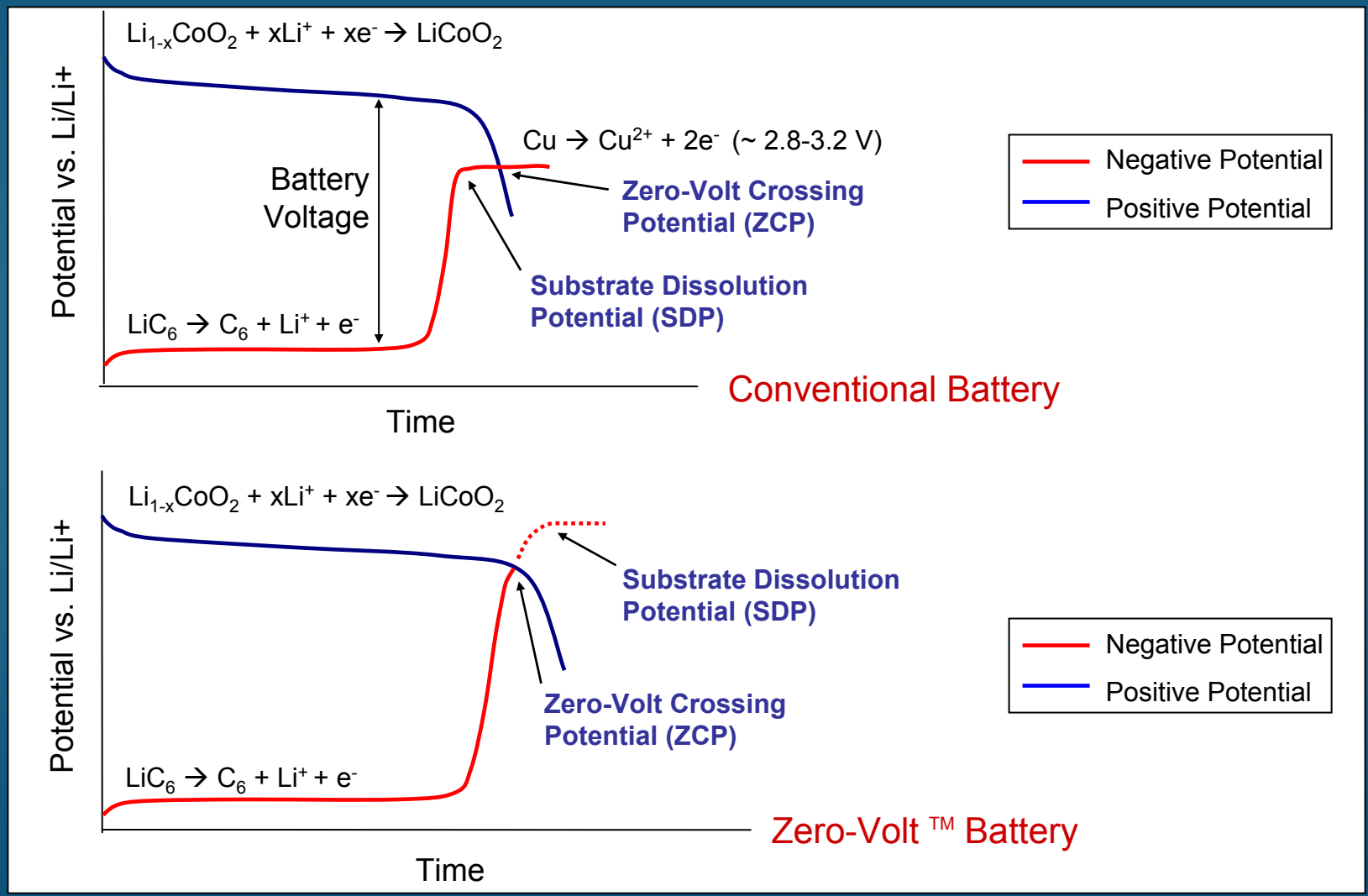
QUALLION®

Powering Life.™

1. Zero Volt Storage Capability



United States Patent 6,596,439 and 6,553,263

Metal Polarization Test

Reference Electrode

Counter Electrode
Disassembled

Counter Electrode
Assembled

Working Electrode

38 mm x 38 mm square

Polished with SiC sandpaper

Ultrasonically Cleaned

Vacuum dried overnight

Polarization Test Cell

Test Conditions

$LiPF_6$ EC:DEC

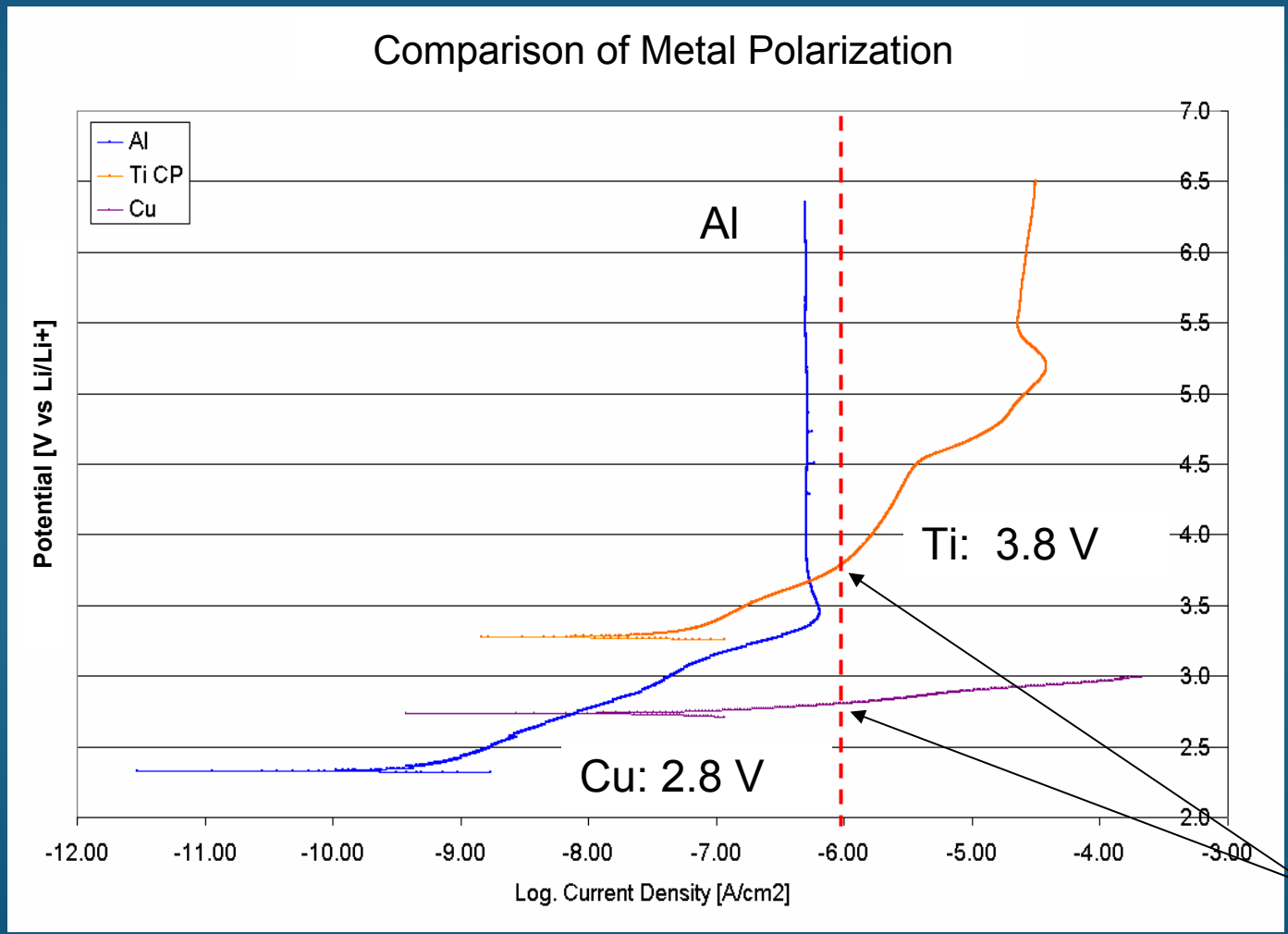
37° C

Scan Rate: 0.167mV/s

Testing inside a Glove box

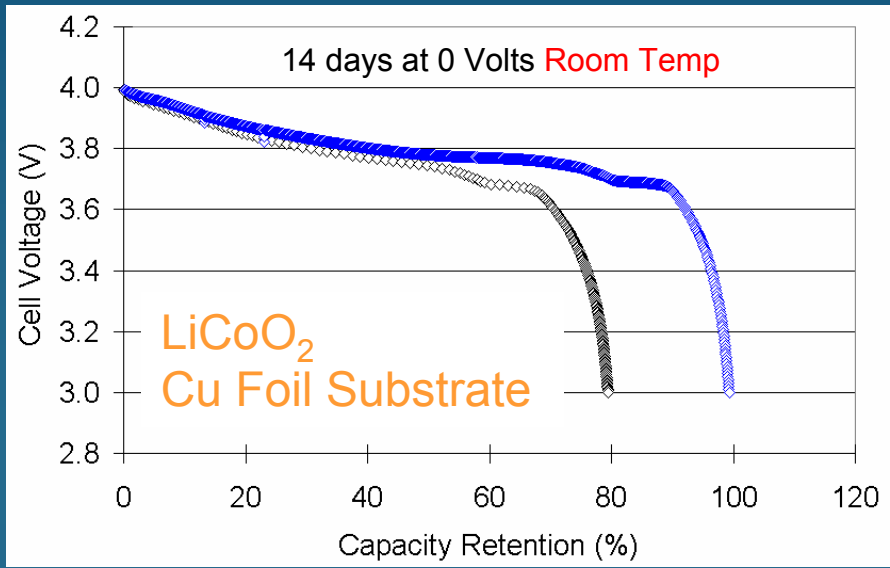
Working Area 1.98 cm^2

Polarization Curves



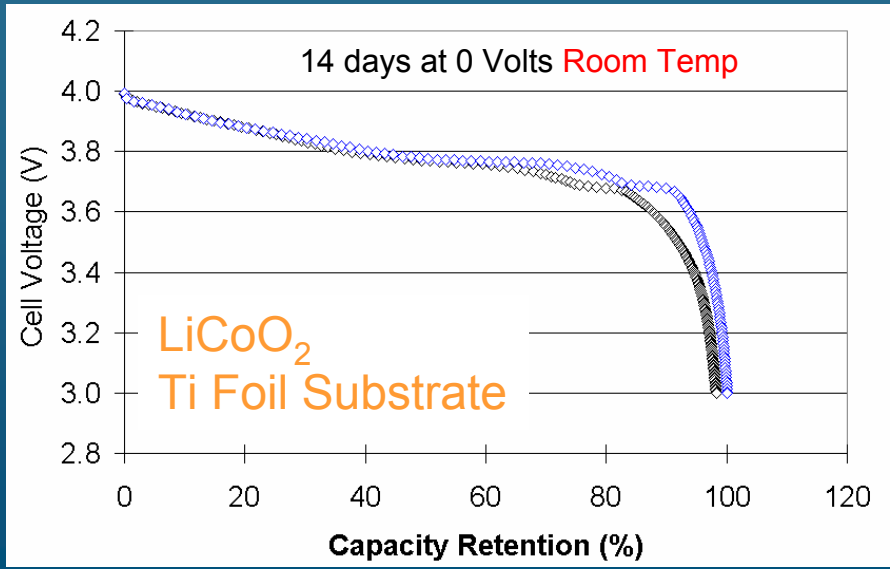
$LiPF_6$ EC:DEC at 37° C, Scan Rate: 0.167mV/s

Titanium Foil for Negative Substrate



Capacity Retention: 79.9%

CC Charge:	C/10 to 4.0V
CV Charge:	4.0V to C/100 cutoff
Discharge:	C/10 to 3.0V
Temperature:	Room Temp
Storage:	0V, at RT for 14 days



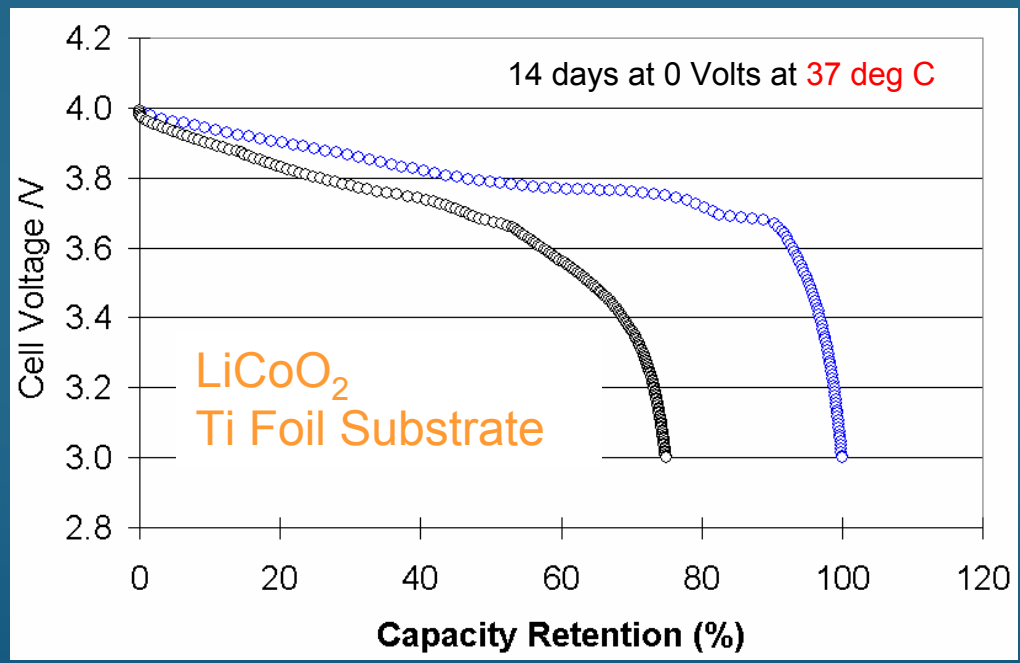
Capacity Retention: 98.6%

Titanium Foil for Negative Substrate

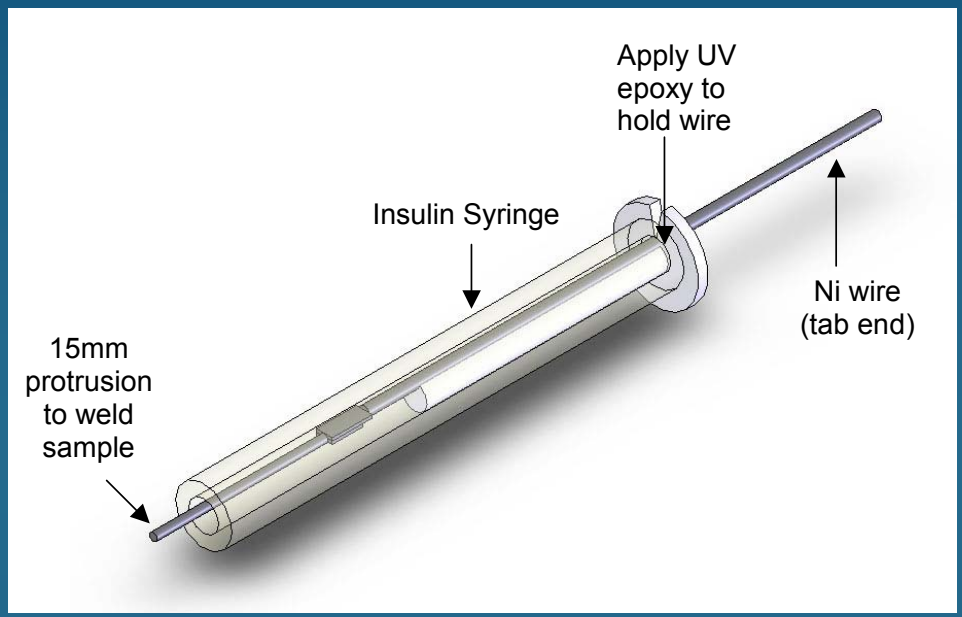
Did not have zero-volt storage capability at 37C storage

CC Charge:	C/10 to 4.0V
CV Charge:	4.0V to C/100 cutoff
Discharge:	C/10 to 3.0V
Storage:	0V, at 37 deg C for 14 days

Capacity Retention: 73.5%



AC Impedance / Cyclic Voltammetry Testing

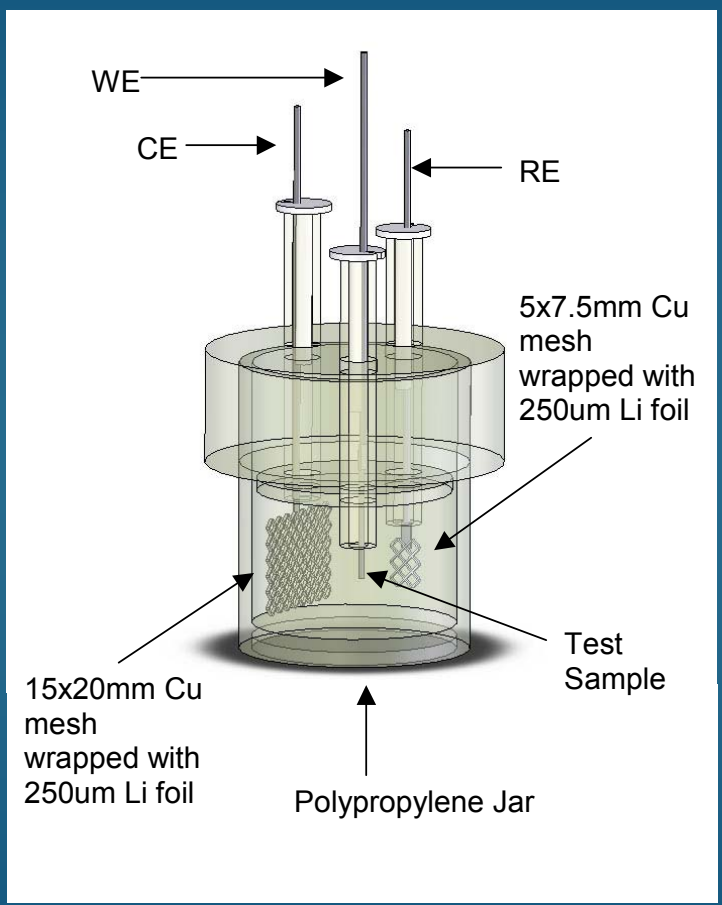


Test Conditions

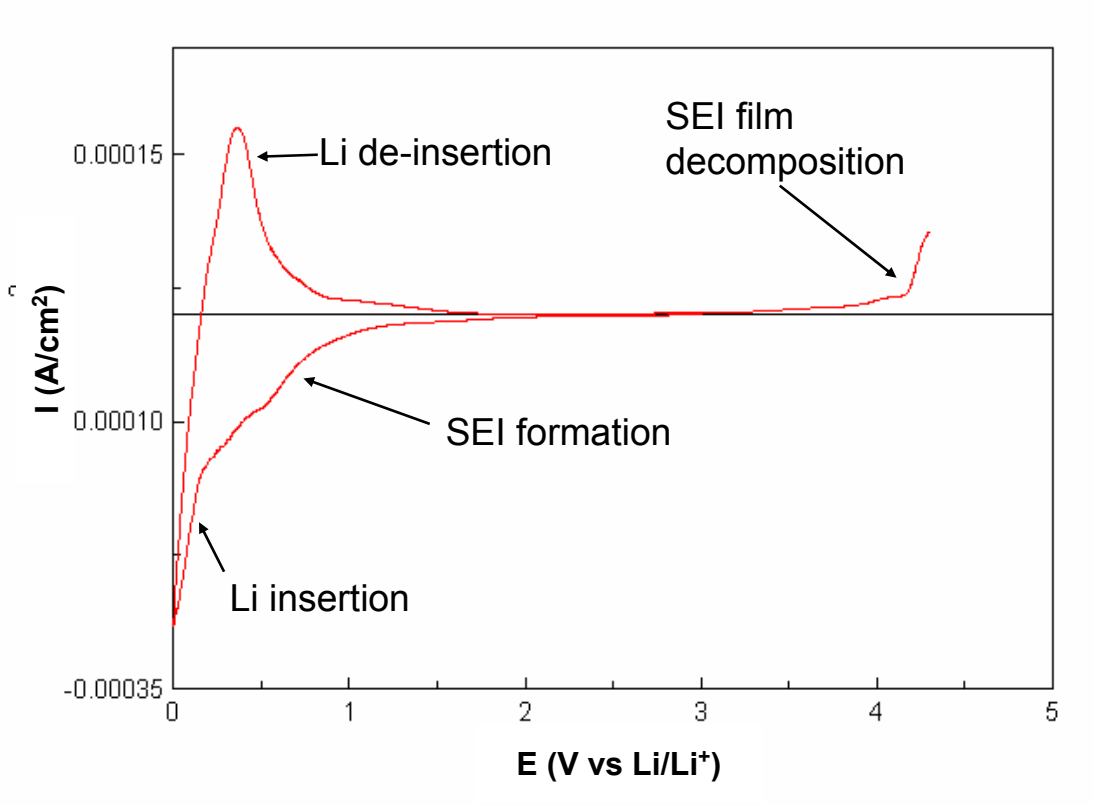
$LiPF_6$ EC:DEC

RT or 37° C

Testing inside a Glove box



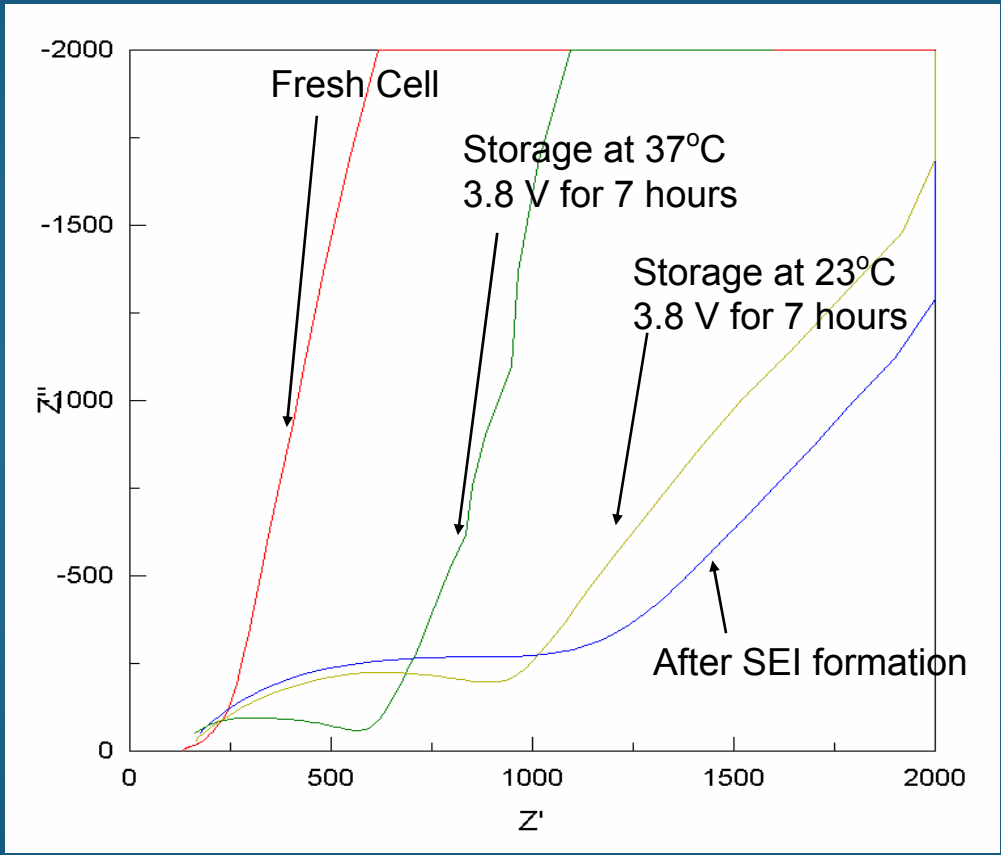
Negative Electrode Cyclic Voltammetry Scan



Graphite electrode on platinum pin

Negative Half Cell; $LiPF_6$ EC:DEC at 25° C; Scan Rate: 0.2 mV/s

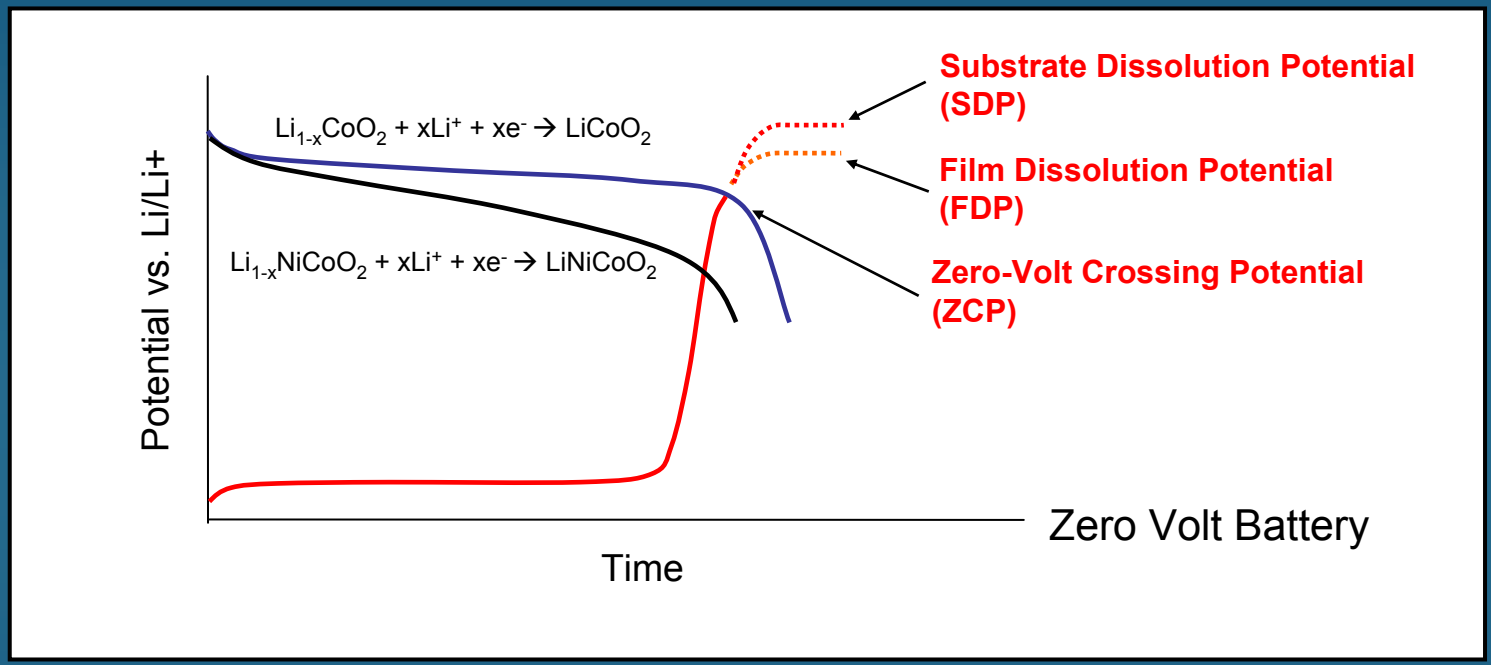
SEI Decomposition



Negative Half Cell; $LiPF_6$ EC:DEC at 25° C;
100kHz – 0.05 Hz

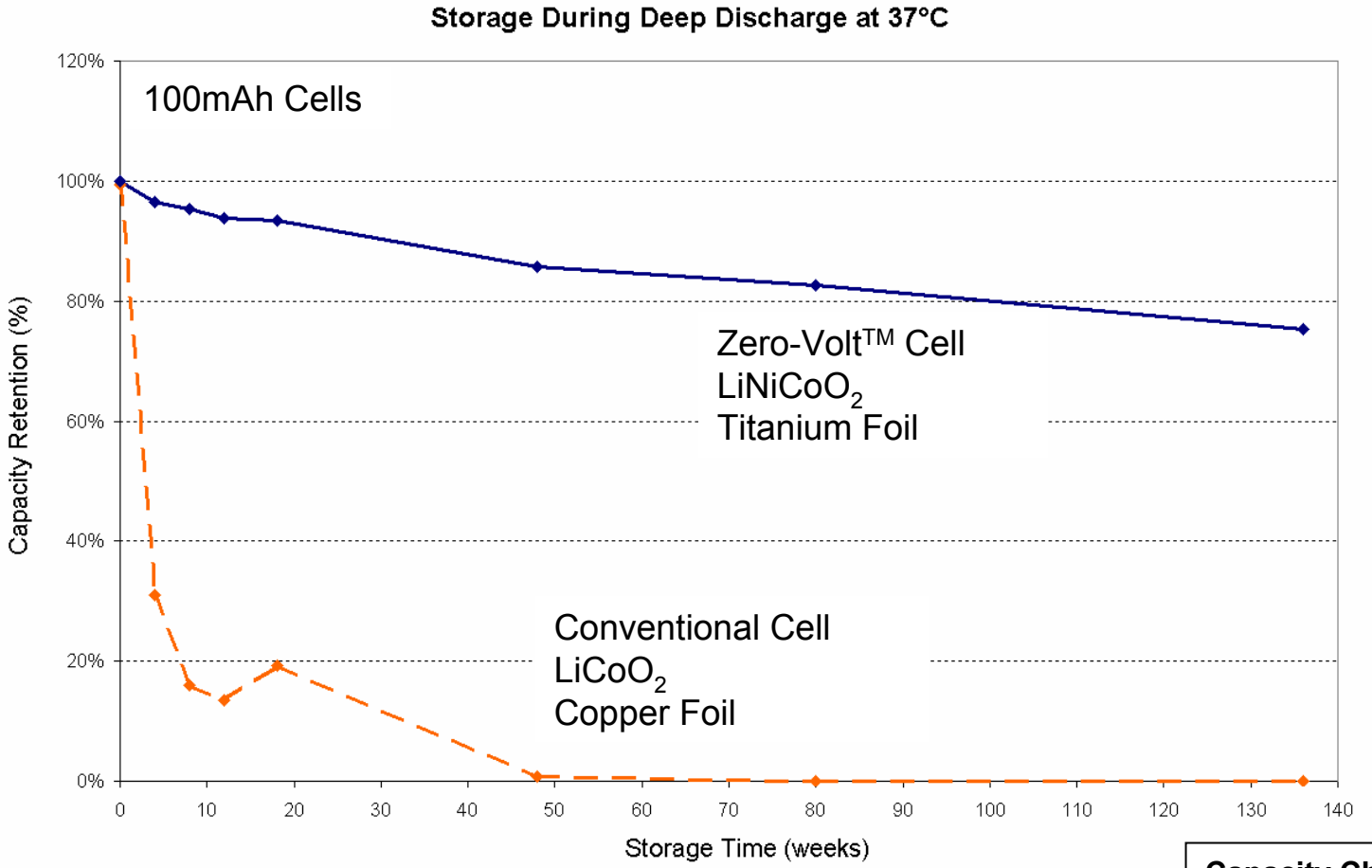
After the storage time at 37°C, impedance decreased indicating that the SEI Film has decomposed.

Three Key Potentials



ZCP < FDP and ZCP < SDP

Zero-Volt™ Storage Capability



Zero-Volt™ Storage Testing

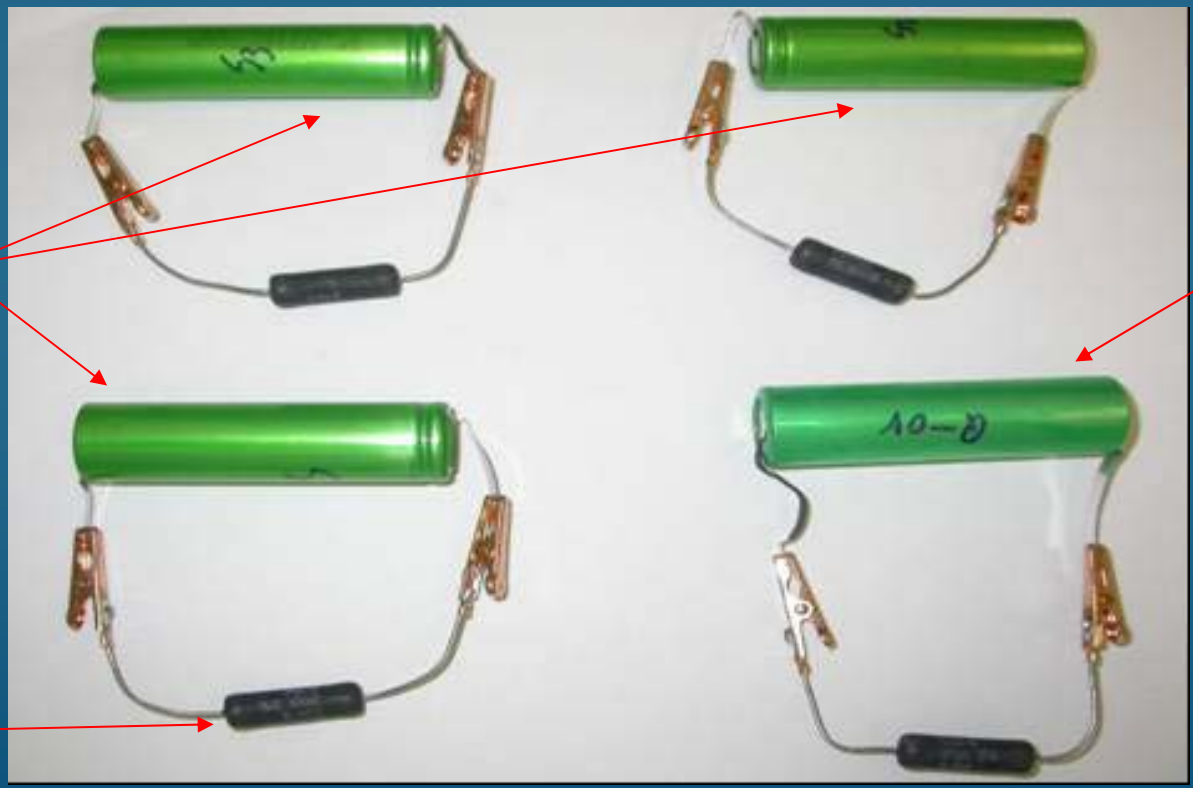
1. Initial cycle
2. Connect 68 Ohm resistor and store at 37°C
3. Cycle after storage
4. Compare discharge capacities before and after storage

United States Patent 6,596,439 and 6,553,263

Capacity Check Cycle

CC Charge:	C/2 to 4.1V
CV Charge:	4.1V to C/20 cutoff
Discharge:	C/2 to 2.7V
Storage:	0V, at 37 deg C

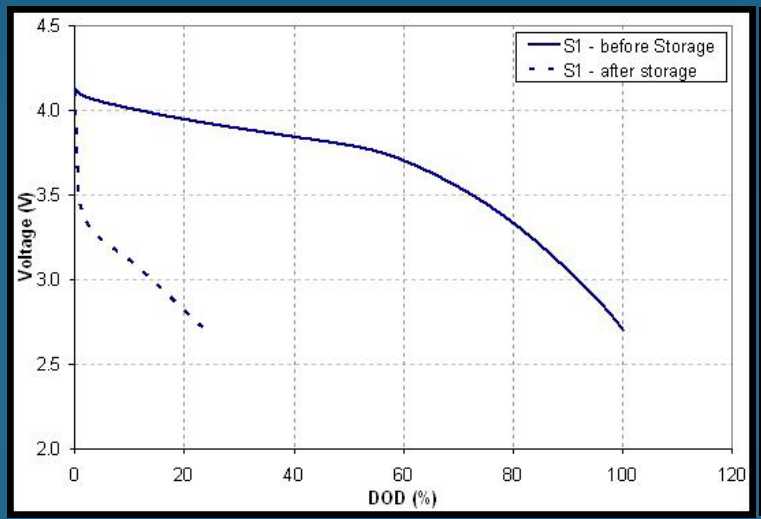
SONY hard carbon cell vs. Quallion zero-volt 18650 cells



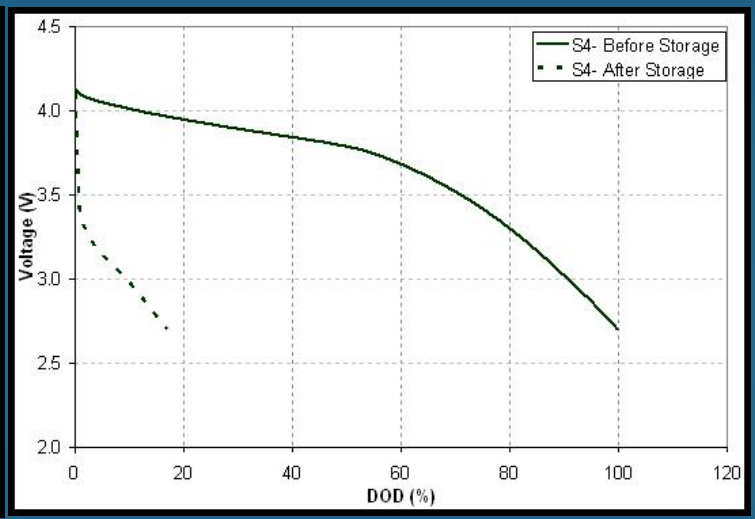
SONY hard carbon cell vs. Quallion zero-volt cells

-Before and After 3 days Storage at Zero Volt-

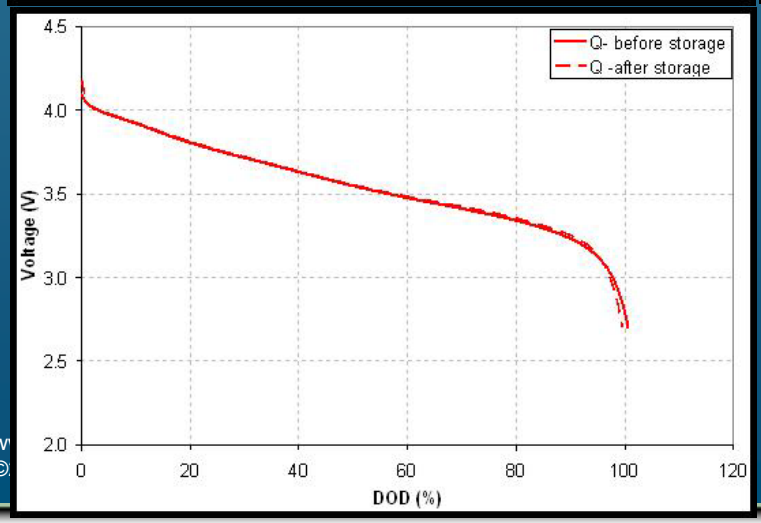
Room temperature storage

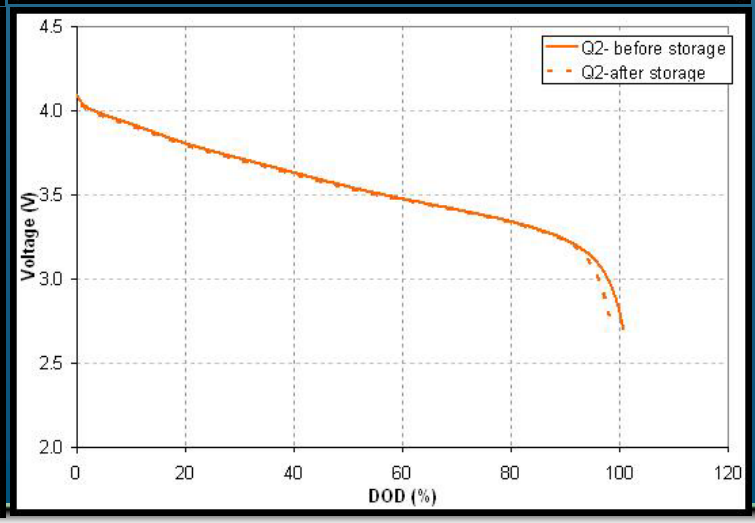


40C storage



SONY Hard Carbon 18650

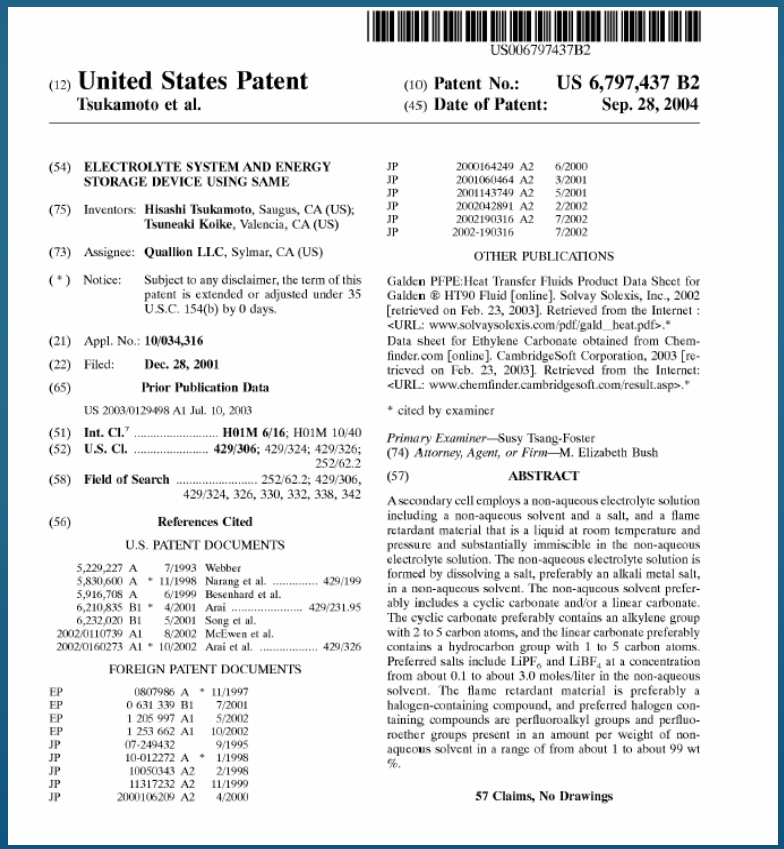




Quallion zero-volt 18650

2. What is SaFE-LYTE™ ?

Electrolyte immiscible additive



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(12) **United States Patent**
Tsukamoto et al.

(10) **Patent No.: US 6,797,437 B2**
(45) **Date of Patent: Sep. 28, 2004**

(54) **ELECTROLYTE SYSTEM AND ENERGY STORAGE DEVICE USING SAME**

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(73) Assignee: **Quallion LLC**, Sylmar, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/034,316**

(22) Filed: **Dec. 28, 2001**

(65) **Prior Publication Data**

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(51) **Int. Cl.**[7] **H01M 6/16**; H01M 10/40

(52) **U.S. Cl.** **429/306**; 429/324; 429/326; 252/62.2

(58) **Field of Search** 252/62.2; 429/306, 429/324, 326, 330, 332, 338, 342

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Primary Examiner—Susy Tsang-Foster
(74) *Attorney, Agent, or Firm*—M. Elizabeth Bush

(57) **ABSTRACT**

A secondary cell employs a non-aqueous electrolyte solution including a non-aqueous solvent and a salt, and a flame retardant material that is a liquid at room temperature and pressure and substantially immiscible in the non-aqueous electrolyte solution. The non-aqueous electrolyte solution is formed by dissolving a salt, preferably an alkali metal salt, in a non-aqueous solvent. The non-aqueous solvent preferably includes a cyclic carbonate and/or a linear carbonate. The cyclic carbonate preferably contains an alkylene group with 2 to 5 carbon atoms, and the linear carbonate preferably contains a hydrocarbon group with 1 to 5 carbon atoms. Preferred salts include $LiPF_6$ and $LiBF_4$ at a concentration from about 0.1 to about 3.0 moles/liter in the non-aqueous solvent. The flame retardant material is preferably a halogen-containing compound, and preferred halogen containing compounds are perfluoroalkyl groups and perfluoroether groups present in an amount per weight of non-aqueous solvent in a range of from about 1 to about 99 wt %.

57 Claims, No Drawings

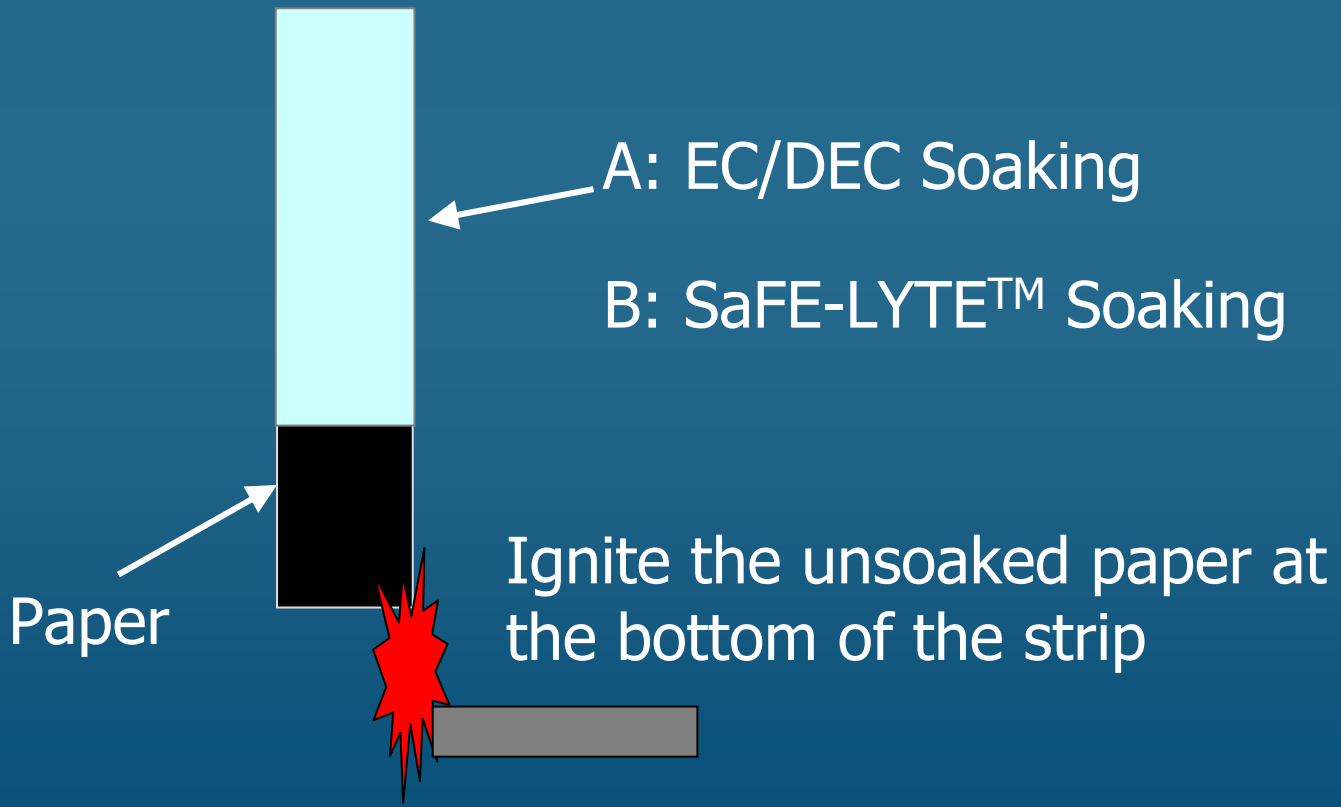
Issued on 9/28/04
Patent No. 6,797,437

Claim 1

"substantially immiscible in the non-aqueous electrolyte solution"

What is SaFE-LYTE™?
Self-extinguishing additive

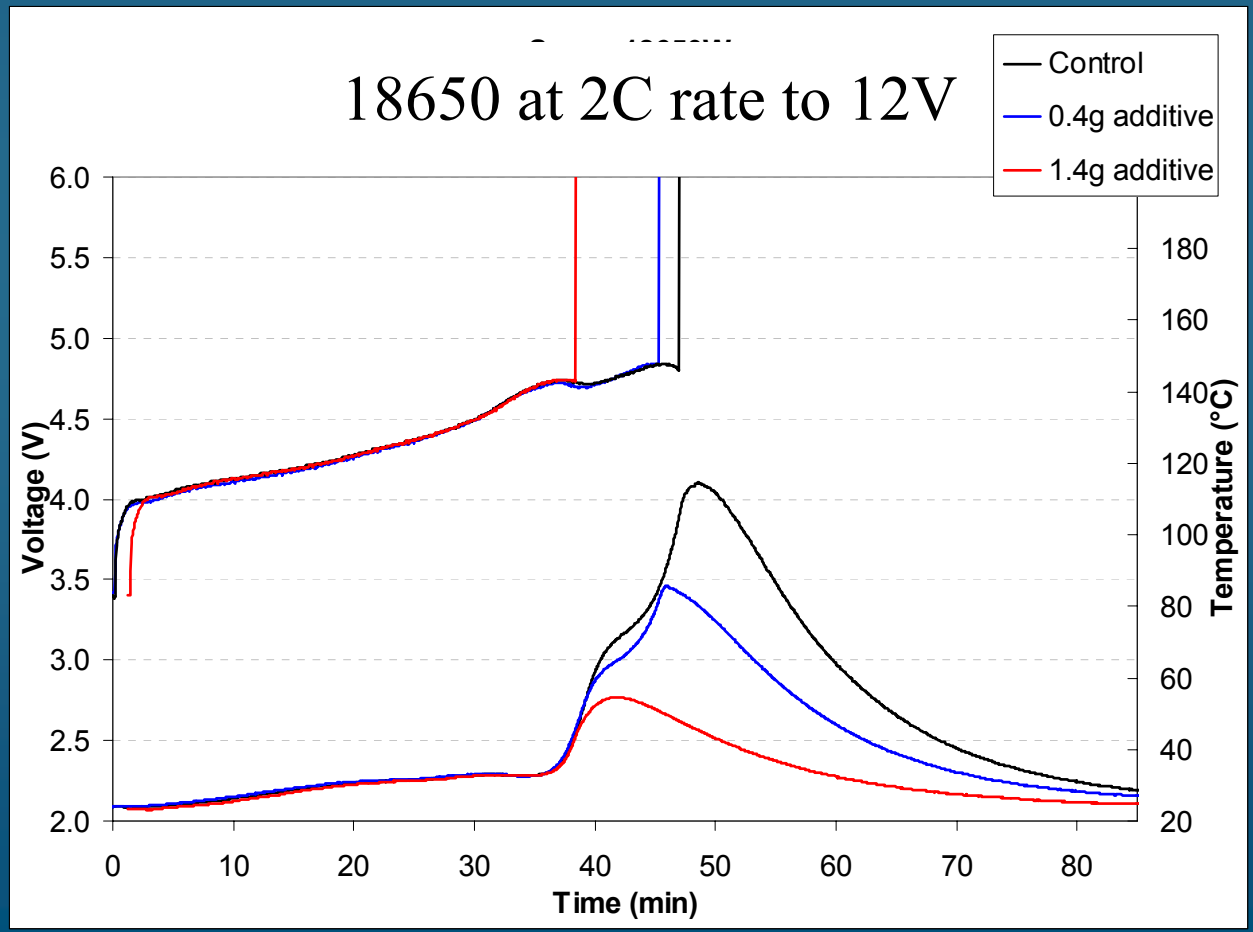
Flammability Test



What is SaFE-LYTE™?
Self-extinguishing additive

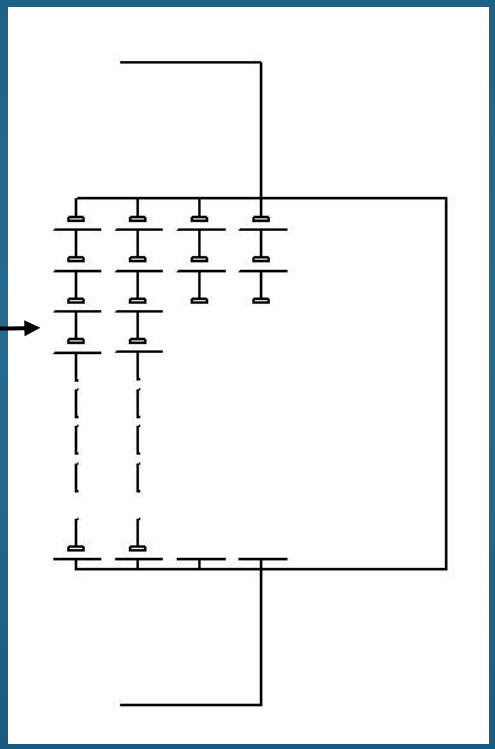
18650 + SaFE-LYTE™

SaFE-LYTE H : >220C
Cathode thermal reaction temperature: 170-190C
SaFE-LYTE M : 160C

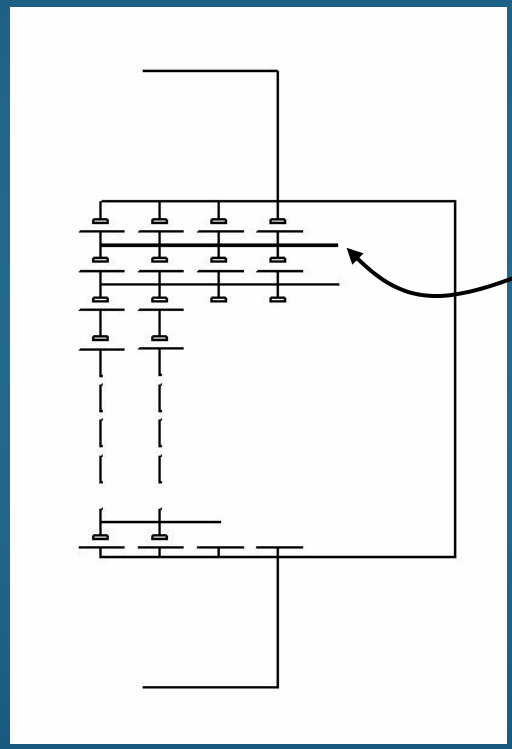


3. Matrix Battery Pack

No parallel connections



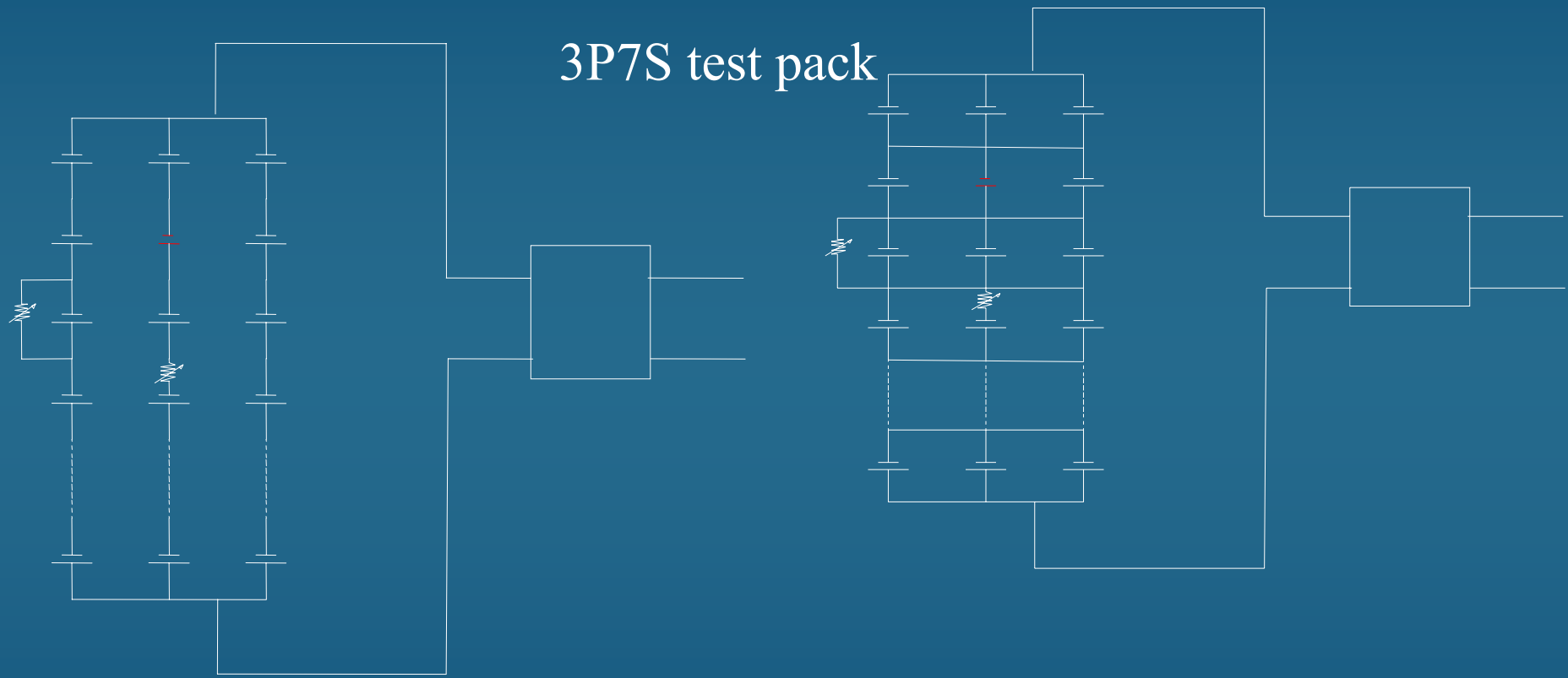
Conventional Battery Pack



Parallel connections

Matrix Battery Pack

Survivability Comparison

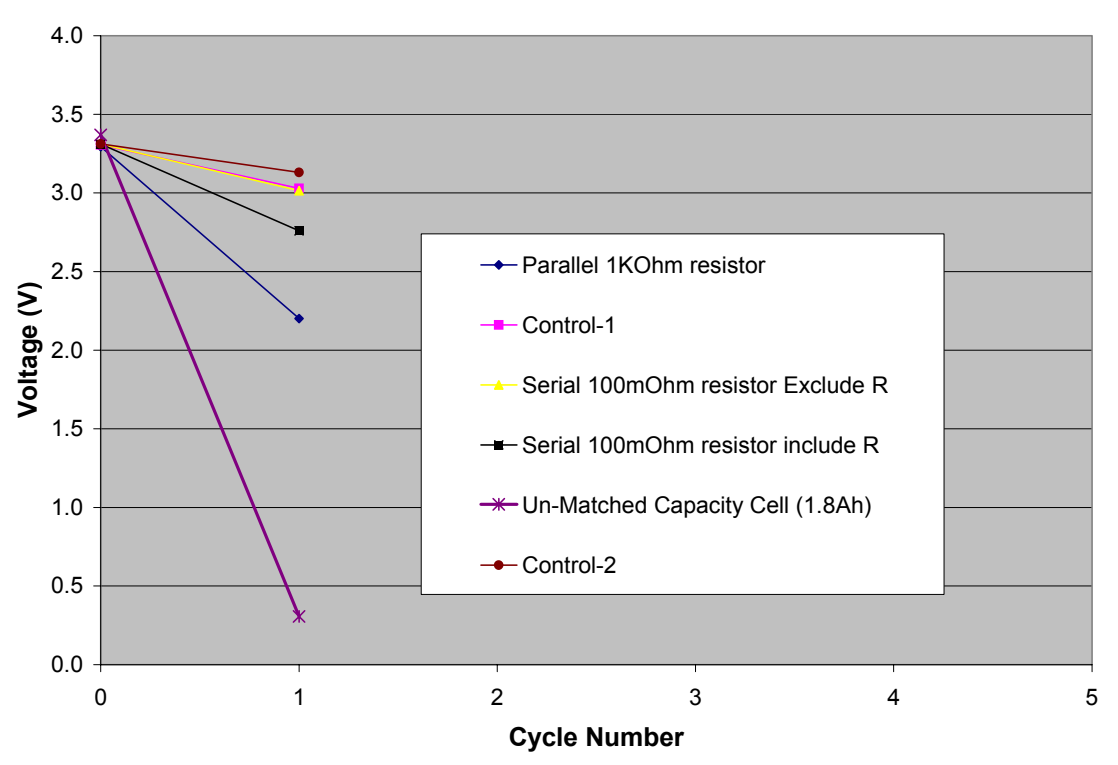


F1 self-discharge

F2 high internal impedance

F3 decreased capacity

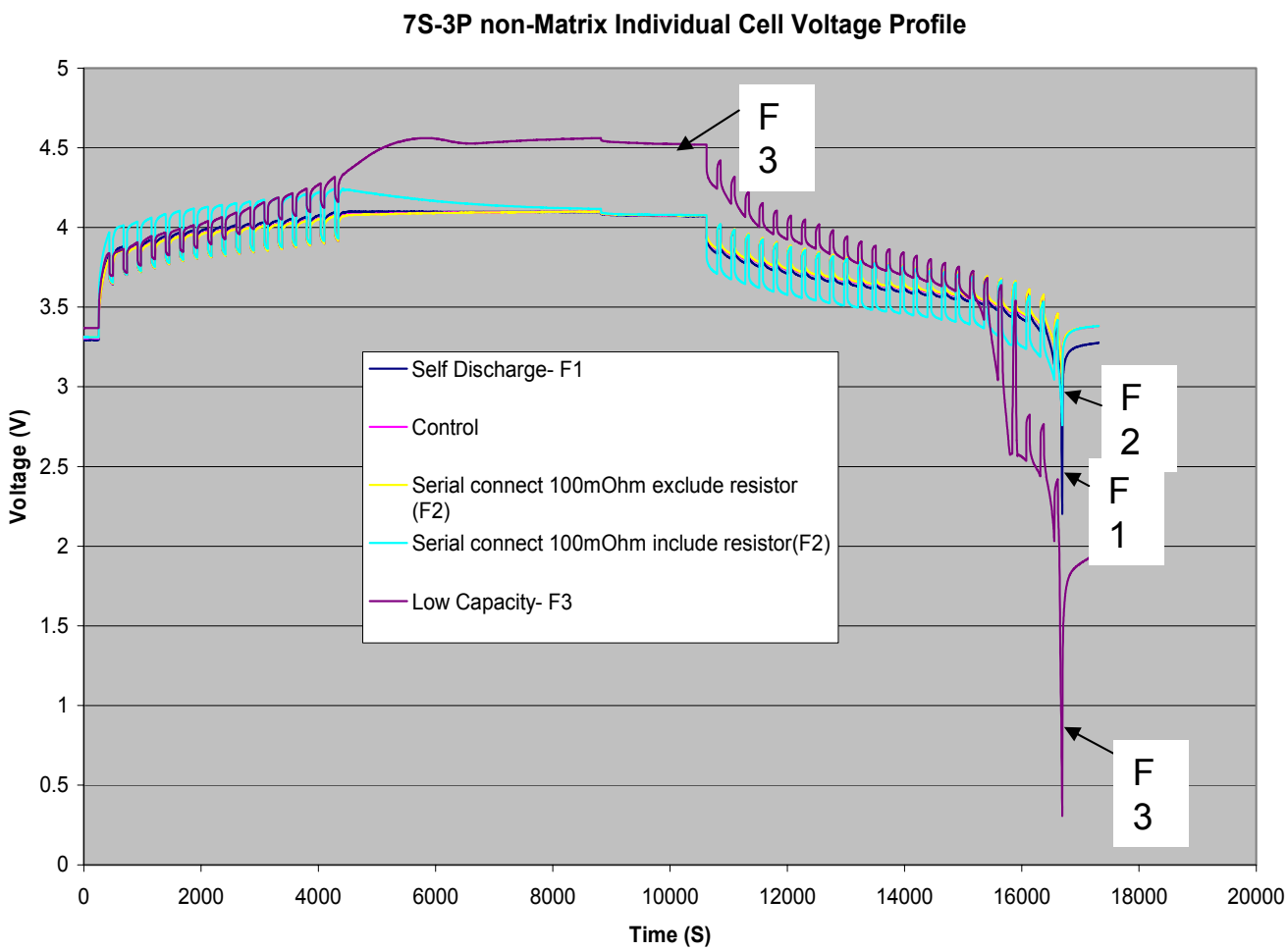
Conventional pack test results
F1, F2, F3 failures



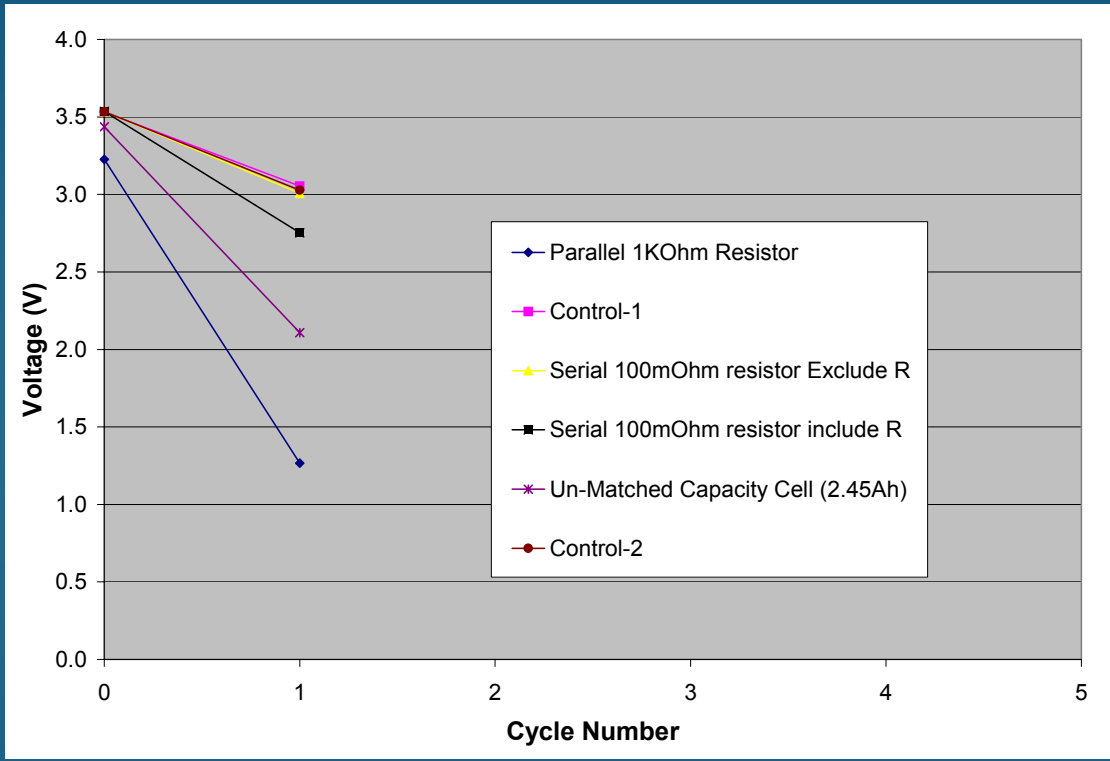
100% DOD
Room temperature
29.4 V
18.9 V

The conventional pack cannot survive more than one cycle with three failure modes present.

Conventional battery pack -1st cycle-



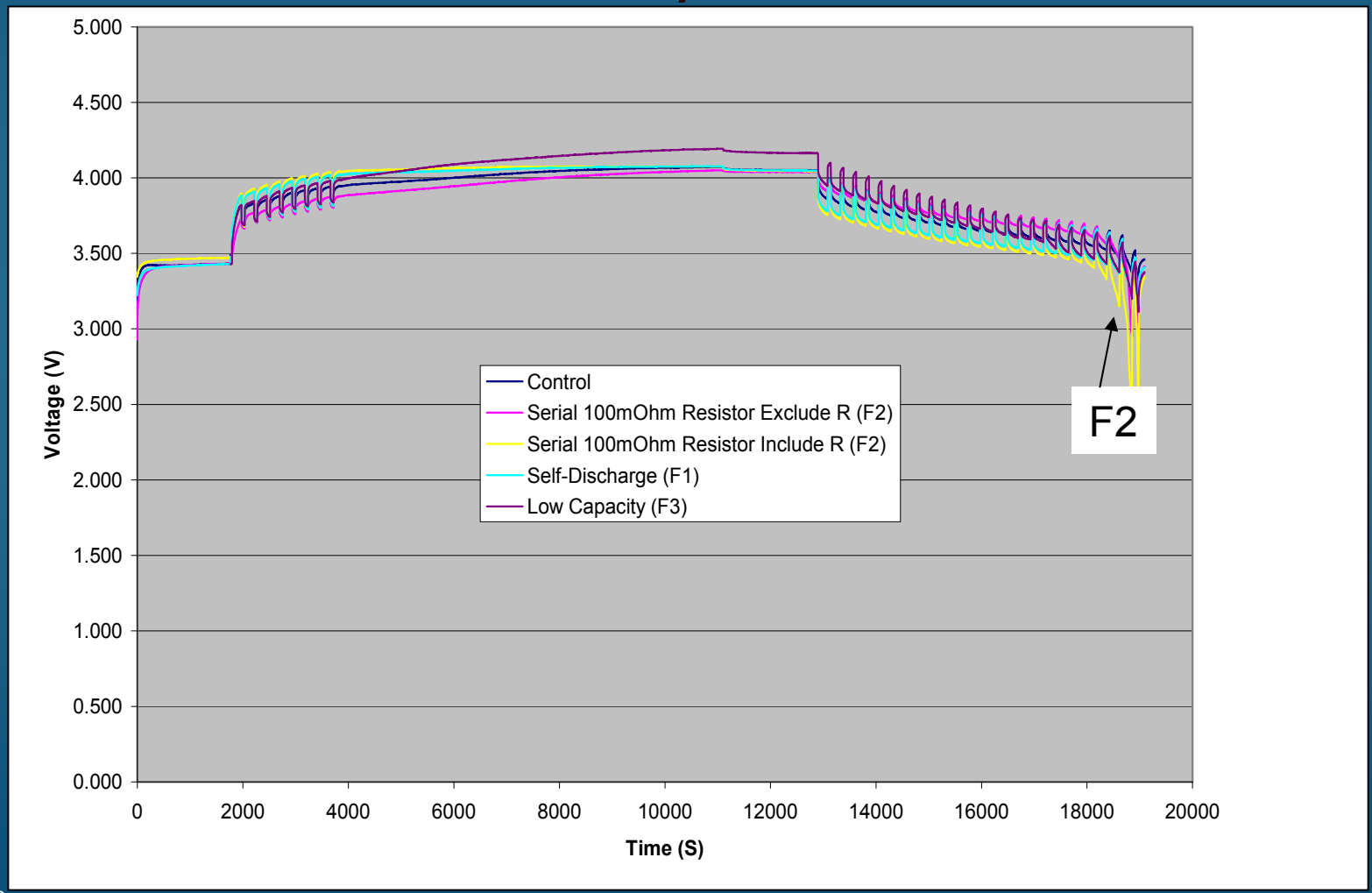
Conventional pack results, F1 and F2



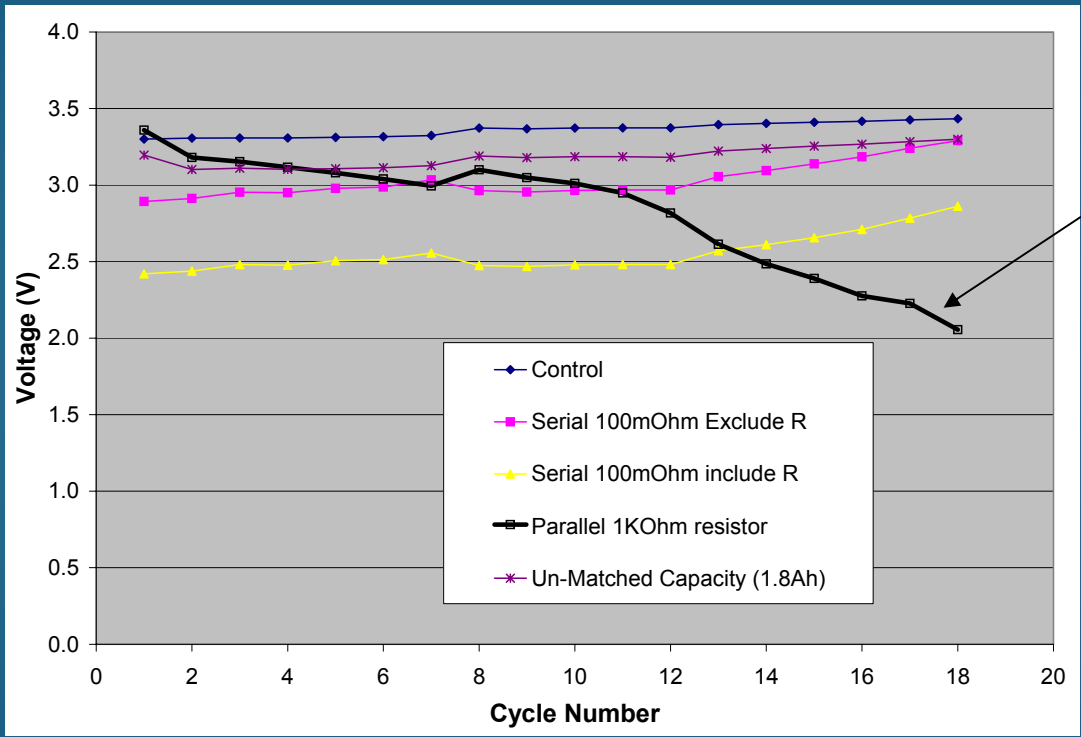
100% DOD
Room temperature
29.4 V
18.9 V

- Even after replacement of the unmatched capacity cell with a correct capacity cell, the voltages still drop.

Matrix Battery Pack
-1st cycle-



Quallion Matrix Pack Test Results F1, F2, F3

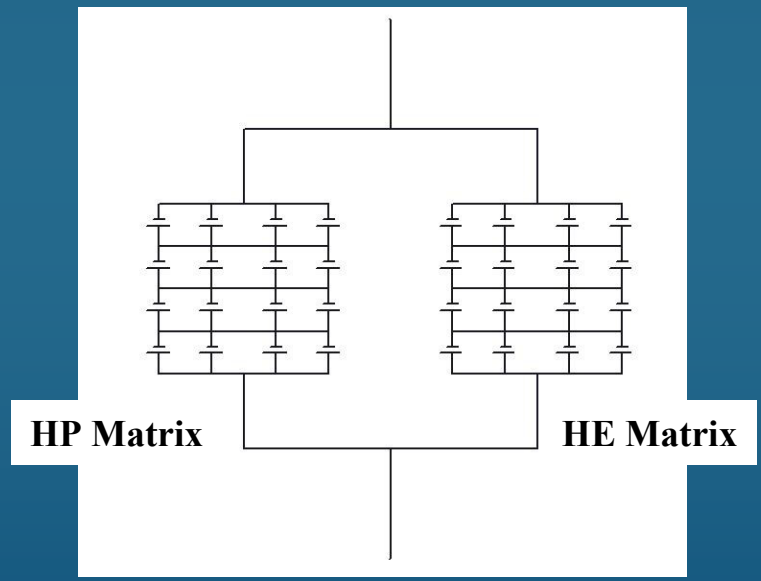


- Voltages of individual batteries under failure conditions are able to maintain operational voltage levels.
- Only one cell under the self-discharge condition loses its voltage, but only when nearing 20 cycles.

Hybrid Matrix Battery Pack

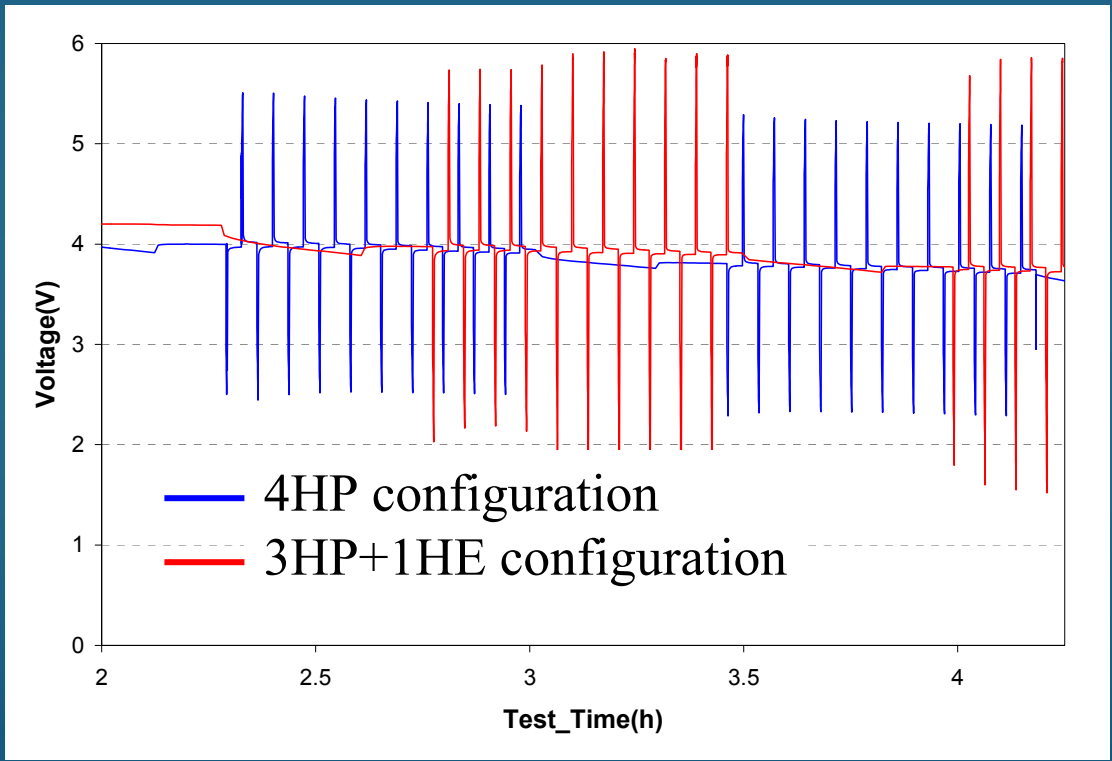
Matrix Battery Pack Can Accommodate Different Capacity and Impedance Cells if Needed

	HP Cells	HE Cells
Energy density	120Wh/kg	200Wh/kg
Power density	1000W/kg	200W/kg



HP+HE: Flexible Performance

-15C pulse test-



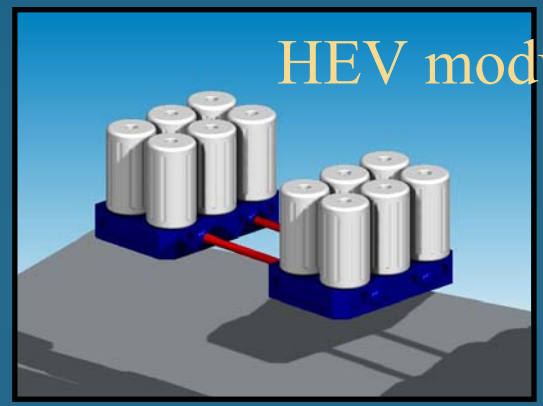
- 4HP: configuration has a smaller voltage drop
- 3HP+1HE: slightly larger voltage drop but more capacity

15C x 10 sec. pulse discharge, 2 min. rest, 15Cx 10sec. pulse charge

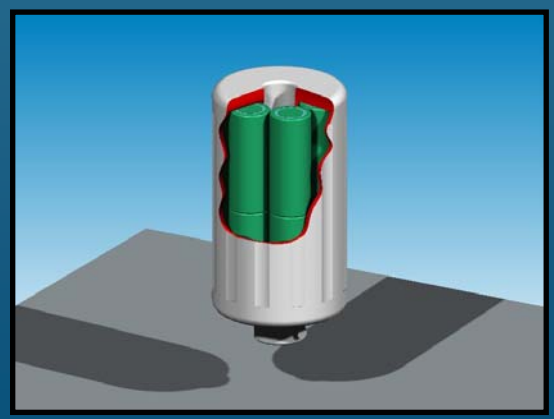
➢ It is possible to vary the battery pack performance characteristics without changing the footprint of the battery pack.

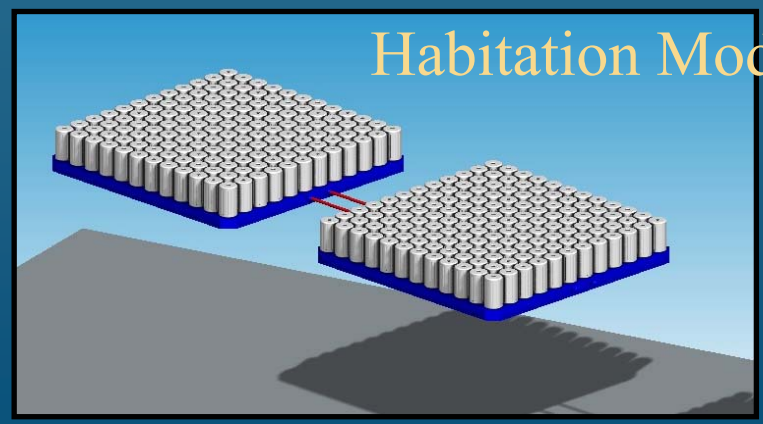
Modular Approach with Matrix Battery Pack

- **Modular pack**
  - **Reduces the complexity of many cells**
  - **Interchangeable and reconfigurable**
  - **HE module pack and HP module Hybrid pack**



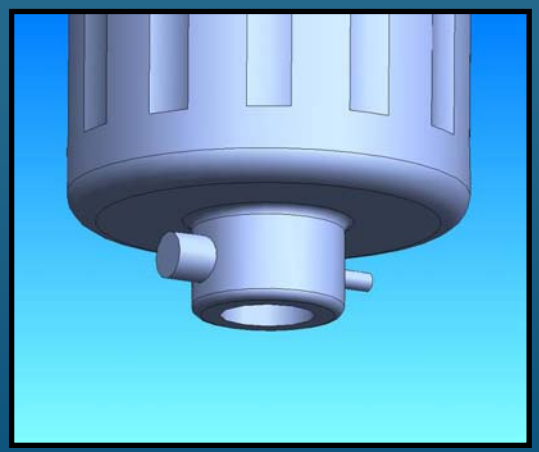
10P of 3Ah cell
30Ah Modular Pack

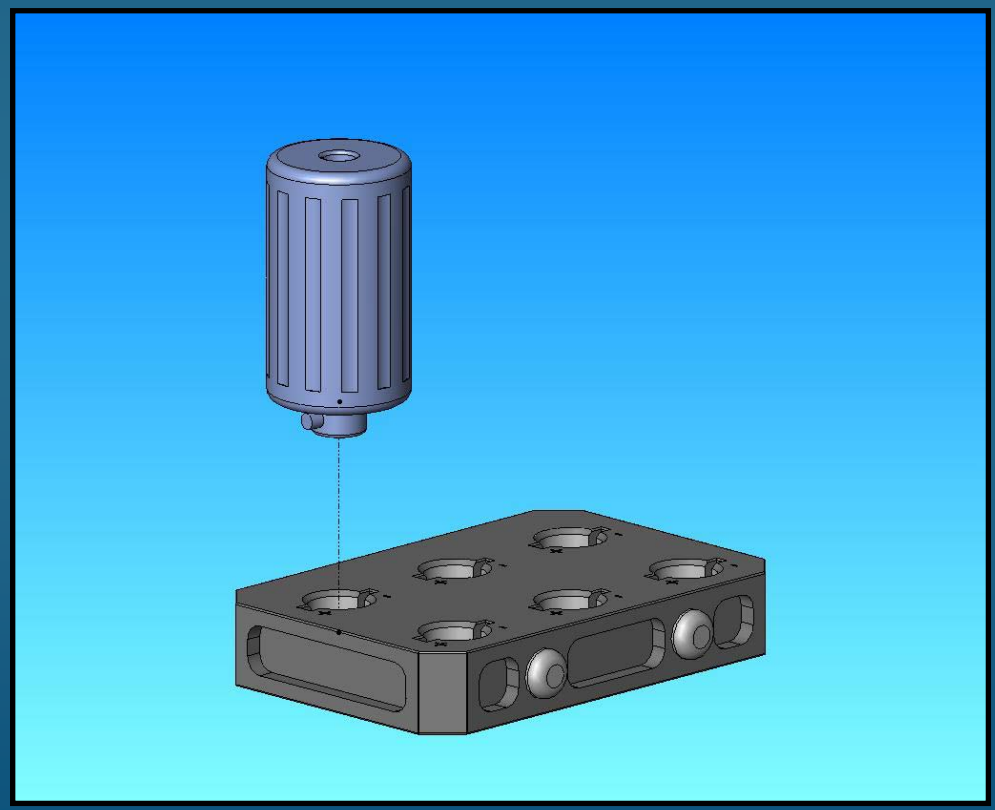




Re-configurable on earth and in space
-Matrix + Modular-

- **Easily changed**
- **Simple connections**
- **Configurable on the fly**





Quallion Technology

1. Zero-volt capability
   - Range safety (battery assembly at discharge state)
   - In space storage without maintenance charge
2. SaFE-LYTE™
   - Significant safety improvement in combination with Current Interrupting Device
3. Matrix Battery Pack
   - Improve reliability and survivability
   - HP + HE hybrid pack
   - Modular approach